Elements of Perceptual Decision-Making: Neuroimaging with a Dot-Motion Task

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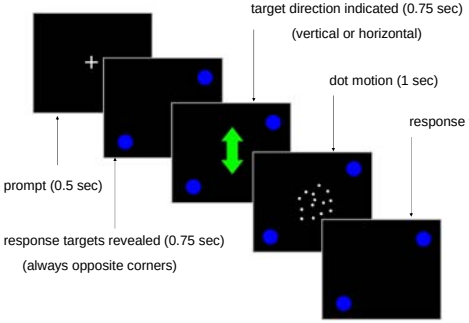
Introduction

- Perceptual decision-making (i.e. making decisions about perceptual stimuli) involves many processes, including searching for evidence, evaluating evidence that is obtained, resolving conflict, and dealing with errors.
- Single-unit recording studies of perceptual decision-making, involving detection of coherent dot motion, indicate that some cells (in MT and LIP) serve as accumulators of evidence (Britten et al, 1992; Shadlen and Newsome 2001).
- Neuroimaging has the potential to reveal other brain regions involved in perceptual decision-making processes. A recent study (Heekeren et al, 2004) examined perceptual decision-making with face and house stimuli.
- The current experiment allows for fMRI investigation of several different component processes of perceptual decision-making, using similar dot motion stimuli to those used in the single-unit studies. This will allow for direct comparison of results from two methodologies, and may suggest additional brain regions appropriate for future single-unit recording studies.

Experimental Paradigm

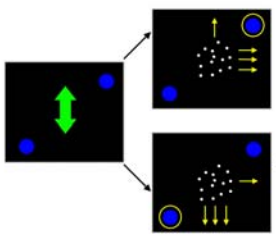


Siemens Trio 3T
34 slices
TR = 2.0 sec
4 runs, 300 volumes/run
8 conditions, 40 reps/cond

Conditions

- congruent vs. incongruent
- high coherence vs. low coherence target
- high coherence vs. low coherence distractor

conHH, conHL, conLH, conLL, incHH, incHL, incLH, incLL

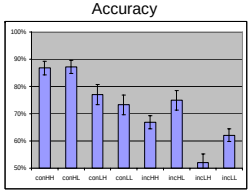


CONGRUENT
LOW target
HIGH distractor
(conLH)

INCONGRUENT
HIGH target
LOW distractor
(incHL)

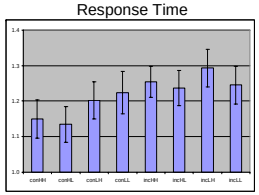
Behavioral Results

Accuracy



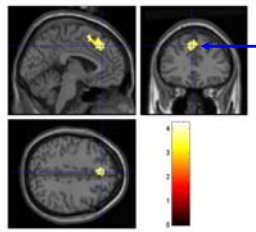
N = 14

Response Time



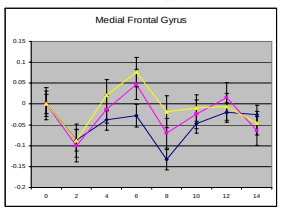
High-level decision processes: conflict, error, and cognitive control

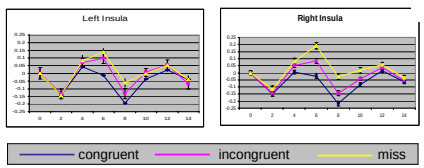
Conflict: *incongruent-congruent*



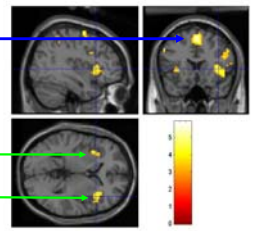
medial frontal gyrus
BA 8/6/32

insula / inferior frontal gyrus
Left: p < 0.005
Right: p < 0.001
(c.f. Hester et al, 2004)



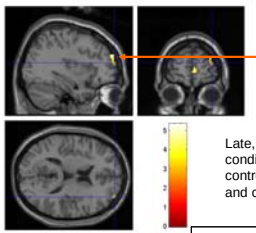


Error: *incorrect - correct*



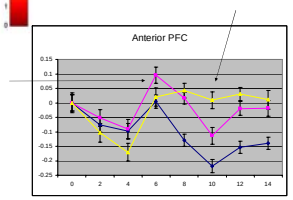
Control: *previous incorrect – previous correct*

Trial-to-trial adjustments following mistakes reflect engagement of cognitive control.



Anterior PFC
BA 10

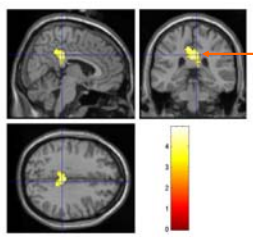
Late, sustained activation for incorrect condition suggests engagement of control after error/difficulty is determined, and carrying over into subsequent trial.



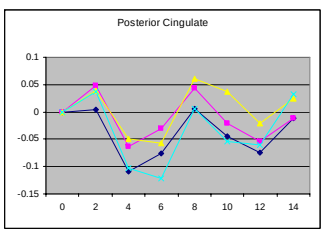
Early activation for incongruent condition suggests engagement of control when conflict is detected. Sustained activation indicates that control affects the subsequent trial.

Low-level decision processes: accumulation of evidence

Easy detection of coherent motion: *any high – all low*



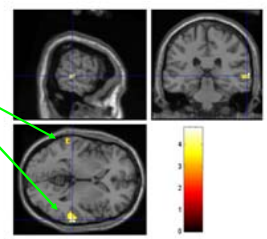
posterior cingulate
BA 31
*(6, -33, 33)



- Posterior cingulate activation increases with a single strong motion direction (vs. low/low or high/high). Thus, this region appears to reflect net evidence.
- Examination of the activation timecourse suggests preferential activation for a single strong direction of motion (HL,LH > HH,LL).
- c.f. Heekeren et al 2004: posterior cingulate cortex activated in a contrast between easy detection and difficult detection (of degraded houses and faces)

Difficult detection of coherent motion: *all low – any high*

middle temporal gyrus
BA 21
*(66, -30, 0), (-66,-39,-3)



- MT is regarded as the locus of motion evidence accumulation (Mazurek et al 2003, Cerebral Cortex).
- Microstimulation of MT speeds perceptual decisions (Ditterich et al 2003, Nature Neuroscience).
- Timecourse pattern reveals HH, HL, LL > LH. This may indicate suppression when irrelevant evidence is strong.